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ABSTRACT

The underlying theme of this review is that fine motor assessment for skills acquired during the first year of life includes a description of the coordination of reach and grasp behaviors into functional understanding, purposeful retention of an object, and manipulation. The developmental sequence of these responses is listed in various standardized/nonstandardized assessment tools, all of which rely on occurence/nonoccurence measures of the response in order to monitor development. Accurate assessment of these responses allows for a finer monitoring of training procedures, provides a method of accountability, and assists in the development of effective intervention procedures. Six standardized assessment tools evaluating fine motor development are reviewed and reported: Assessment in Infancy, Neonatal Behavior Assessment Scale, Developmental Diagnosis, Bayley Scales of Infant Development, Denver Developmental Screening Test, and Koontz Child Development Program. Sixteen nonstandardized scales are also reviewed and compared. Significant developmental stages of reach and grasp sequences are summarized in tabular form, reflecting the amount of information available compared with the data showing the development of midline skills and motor release. (Author/GK)

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Review of Measurement Instruments and Procedures for Assessing Reach and Grasp Behaviors: Implications for Quantitative Measurement

BY

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REVIEW OF MEASUREMENT INSTRUMENTS AND PROCEDURES FOR ASSESSING REACH AND GRASP BEHAVIORS: IMPLICATIONS FOR QUANTITATIVE MEASUREMENT

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Fine motor assessment for skills acquired during the first year of life includes a description of the coordination of reach and grasp behaviors into functional prehension, purposeful retention of an object, and manipulation. The developmental sequence of these responses are listed, more or less completely, in a variety of standardized and non-standardized assessment tools. Regardless of whether the assessment instruments differentiate grasp from reach, they all rely on simple occurrence/non-occurrence measures of the response in order to monitor development. Research identifying the development of prehension has described a variety of observation and recording devices and procedures impractical for most interventionists because of the expense of equipment, number of persons required, or time involved. The unavailability of precise recording procedures has restricted measurement to very gross differentiations of a grasping response and it has limited the identification of a reach to "sweeps" or "directed reach." Most assessment instruments require that a response be well established or spontaneous before credit is given to the child. This eliminates accurate measures of the emergence of reach and grasp response.

The importance of the reach and grasp responses is evident in almost all interactions with the environment. Those persons who do not develop functional prehension of some type are restricted in their ability to independently investigate, and therefore to learn, from their surroundings. A more accurate assessment of the emergence of a reach or grasp, or the small increments of change that occur in their development, will allow for a finer monitoring of training procedures, provide a method of accountability for the interventionists, and assist in the development of effective intervention procedures.

Standardized Developmental Scales and Checklists

Six standardized assessment tools that evaluate fine motor development were reviewed. They were selected because they included behaviors appearing prior to 12 months, they sequenced the behaviors in some developmental progression, they presented the behaviors in measurable and observable terms, and they specifically indentified items related to reach and/or grasp responses. Each instrument was reviewed with respect to the measurement or observation techniques used during the evaluation, directions given to the evaluator in terms of positioning and materials, and component behaviors identified as significant for the acquisition of prehension.

The physical structure or timing of the observation and evaluation sessions were usually not delineated, leaving the setting and conditions of testing to the evaluator. The Assessment in Infancy (Uzgiris and Hunt, 1975) suggested that the evaluation could be done in the home when the child is alert and playful. The Neonatal Behavior Assessment Scale (Brazelton, 1973) and (Note 1) suggested a more controlled setting, (in a quiet environment) beginning when the infant was asleep and gradually introducing specific stimuli while monitoring stages of awakening. Even though the Developmental Diagnosis (Gesell and Amatruda, 1947), the Bayley Scales of Infant Development (Bayley, 1969), The Denver Developmental Screening Test (Frankenburg, Dodds, and Fandal, 1970), and the Koontz Child Development Program (Koontz, 1974) did not delineate specifics of the evaluation setting, they can be reliably implemented by teachers after a relatively short period of training. Only the Bayley Scale specifically allowed for the parent or care taker to present test items while the evaluator

was present. The other scales only allowed for a single trained evaluator.

All six assessment instruments scored items as either occurrence or non-occurrence data at a grossly specified performance level. None of them requested measures of duration, rate, or latency even for those responses generally viewed as repeated behaviors (i.e., movement of fingers, movement of arms, hand to mouth, or swiping). The Koontz Child Development Program specified that the response had to be spontaneous and naturally occurring rather than elicited, but no specific criteria for judging this response were given. The Neonatal Behavioral Assessment Scale, Developmental Diagnosis, Bayley Scales, Assessment in Infancy, and Denver Developmental Screening Test utilized both spontaneous observation methods and the presentation of stimuli to determine the occurrence of a response. However, most trials included a formal assessment of responses such as grasping pattern, reaching for distant objects, or activation following the visual presentation of a stimulus item. The Denver Developmental Screening Test, Koontz Child Development Program, and Neonatal Behavior Assessment Scale accepted parental reports of such behaviors as hands together at midline, batting, or transferring objects.

The positioning of the individual during assessment, if indicated for separate trials or sessions, usually alternates between the supine and supported sitting positions. Prone or sidelying are not mentioned as positions either to initially assess reach and grasp behaviors, or as alternative positions. The Bayley Scales give general instructions for the arrangement of the evaluation setting with some notes referring to placement of the child in sitting or supine positions. Evaluation

of more advanced grasps are done in a sitting position with a flat surface placed at elbow height. No indication is made whether the sitting position is supported or independent. The Developmental Diagnosis evaluates all initial reaching responses in the supine position with the sitting position used for more advanced reach and grasp responses. The Neonatal Behavior Assessment Scale moves from the use of supine to a position in which the child is held. Identification of behaviors specific to reach (i.e., tone of arm movements and hand to mouth) are only observed in the supine position. The Denver, the Koontz, and the Assessment in Infancy do not indicate what positions are to be used to observe which specific responses. The Denver does suggest a supported surface for assessing more advanced grasping patterns. However, none of the assessment instruments reviewed request observations of the same response in two or more different positions, nor do they suggest how long a position should be maintained before the performance in that position is considered non-representative.

The materials generally used to assess fine motor skills during the first year are a red ring, cube, pellet, raisin, rattle, and string. The Neonatal Behavioral Assessment Scale does not utilize materials but scores on general muscle tone and hand to mouth facility. The Bayley Scales, Developmental Diagnosis, Koontz Child Development, and Denver Developmental utilize the above items without delineating size, shape, and weight. Each of these dimensional characteristics could effect the individual's ability to grasp and retain, or retrieve the materials. The Assessment in Infancy refers to stimuli as objects, suggesting the use of familiar and liked items which, however, might further reduce the reliability of the assessment. The positioning

of the stimulus items, whether dangled or placed, is inferred to be in the midline position. Nevertheless, none of the assessment tools specify if the item should be in midline, nor do they indicate the distance the object should be held from the child's body, nor the duration of the presentation. No alternative positionings of the materials are suggested either for a secondary testing position or to specifically identify the ability to reach or grasp objects in a range of different positions. Finally, it is not clear what, if any, instructions, or verbalizations are to be given along with the presentation of the stimulus items.

The behaviors pinpointed during the early assessments of fine motor acquisition initially differentiate separate topographies for the reach and grasp responses until the individual coordinates the action into one movement involving reach, recovery, and manipulation. Early reach is identified by the Denver Developmental Screening Test if the child moves both the arms and legs equally, by the Bayley Scales if the arms are thrust during play, or later if there is unilateral reaching. Early reach is identified by Developmental Diagnosis if arms activate with the presentation of stimulation and later if there is a two handed approach to items. The Assessment in Infancy identifies early reach if intensified and then repeated arm movements occur with stimulation. Reach responses measured by the Neonatal Behavioral Assessment involve arm movements characterized by smooth or jerky patterns, size of the arcs, overshooting, and by hand to mouth facility. The Koontz Development Program does not assess reach as separate from early grasping. In this scale the identification of the development of the grasp begins

first with an observation of the position of the hand, fisted or loosely open, but the position of the arm is always related to the activity of the hand. Only the Bayley Scales and the Developmental Diagnosis differentiate the type of grasping pattern utilized (ulnar, medial, or radial), while the other scales assess manipulation skills by identifying responses such as recovering, transferring, banging, rotating and regarding, and releasing objects. The establishment of a mature pincer grasp is assessed specifically in Developmental Diagnosis, the Denver Developmental Screening Test, and the Koontz Child Development Program. The Bayley Scale and Assessment in Infancy do not specifically require thumb-finger opposition for credit on more advanced grasping activities.

These standardized assessment tools identify the behaviors observed during the development of grasp, reach, and the manipulation of objects. However, in-depth assessment of the progression between responses or variations of performance within responses is severely limited due to inadequate measures and the lack of systematic instructions to the evaluator. The difficulty of adequate measurement of these behaviors was pointed out by Bayley (1969) who stated, "items showing low test-retest reliability for the motor scale were more variable in type, involving 'emerging' skills in the areas of both fine and gross coordination and tasks requiring the examiner's assistance." (p. 22)

Non-Standardized Assessment Instruments and Procedures

There are a number of non-standardized assessment tools that vary in the amount of the instructions provided for measurement, positioning of the child, and materials used. Of the 16 non-

standardized scales reviewed, six presented directions on the administration of the scale, while the remaining scales only provided developmental lists of behaviors. All sixteen assessments were selected because they listed some fine motor behaviors that occur during the first year of life, they presented the behaviors in a developmental sequence, and they identified the behaviors in terms that could be operationally defined. The six assessment tools that gave instructions for administration were reviewed in terms of the measurement techniques suggested, directions to the evaluator, and the sequence of behaviors to be identified. These instruments include the Callier-Azusa Scale (Stillman, 1977), The Down's Syndrome Performance Inventory (Hayden, Note 2), The Peabody Developmental Motor Scales (Folio and DuBose, 1974), The Learning Accomplishments Profile (LAP) (Sanford, 1974), The Madison Public School Early Childhood Fine Motor Checklist (Funkhouser, Amundsen, Hunt, Smith, Putzer, and Sipsma, Note 3), and The Marshalltown Project, Manual I, (Donahue, Montgomery, Keiser, Roecker, Smith, and Walden, Note 4). The additional 10 assessments were included in order to present a combined list of behaviors pinpointed as significant in the development of functional prehension. Tnese include the Developmental Pinpoints (Cohen, Gross, and Haring, 1976), Early Intervention Developmental Profile (Moersch, Note 5), Infant Learning Program (Gentry, 1977), Performance Objectives Catalogue (Ingham Intermediate School District, 1977), The Manual of Alternative Procedures: Motor Development (McCormack, 1977), Project Memphis (Quick, Little, and Campbell, 1974), the Rural Infant Stimulation Program (RISE), (Holden and Cook, Note 6), The San

Juan Program Checklist (Note 7), The Sequential Assessment and Teaching Guide (Falvey and Greenburger, Note 8), and the Tests for the First Years of Life (Frankl and Wolf, 1935).

Our review of the measurement procedures outlined by the first six assessment tools includes a discussion of instructions about the physical environment or location of the evaluation, whether the response was to be formally or informally observed, how the response was recorded, whether parental reports were accepted, and how much training was required for the evaluator.

Three of the six assessments give some instruction as to the location or environment of the assessment. The other instruments imply that assessment should take place in location convenient for the evaluator. The Callier-Azusa suggests that the assessment be conducted in the classroom, and only after the child has been exposed to that environment for two weeks. The intent is to observe behaviors that typically occur in this setting. The L.A.P. also suggests a familiar classroom for observation. The Madison Public School Fine Motor Checklist is essentially concerned with skills that exist in the environment. Assessment or observations are encouraged to occur in as many natural environments as possible. Home and school settings are suggested with a general recommendation to also include work and leisure environments. None of the assessment scales mention time of day nor do they provide indicators to use as guidelines for when to assess (e.g., mood, degree of alertness, etc.).

All the assessment scales require an occurrence or non-occurrence measure of a particular response, but only three of the scales in-

dicate how a trial is to be determined. The L.A.P., and the Callier-Azusa Scale to a lesser extent, provide guidelines for implementation of an assessment trail or arrangement of an assessment observation. These scales also give loose guidelines for scoring the child's responses as credit, no credit, not applicable, or no opportunity to score. The introduction to the Madison Public Schools Early Childhood Fine Motor Checklist points out that the responses to be observed are functional skills. The checklist assesses how well "a child can perform a meaningful activity in his/her environment, without direct orders..." (p. 3), therefore no systematic cues or mateials are desired. The actual occurrence or non-occurrence of a response is not required to be observed by the evaluator for all the tools. The L.A.P. and the Peabody Developmental Motor Scale will accept parental reports for some select items and the Callier-Azusa encourages a parent to be included on the team of familiar persons evaluating the individual. None of the scales suggest any recording procedure other than the occurrence of the response. Some characterize this occurrence by such terms as "spontaneous," "functional," or "readily observable." However, criteria such as the rate, duration, or latency of the response are not suggested. Nor do these scales give guidelines for the amount of training or performance required of the evaluator before the assessment can be considered valid or reliable. The Callier-Azusa, L.A.P., Peabody, and Madison Public Schools Checklist all encourage familiarity with both the items on the checklist and the individual to be assessed before proceeding, but they do not indicate how to determine when this has been achieved.

Each of the six assessment scales reviewed does present some directions to the evaluator in terms of the positioning of the individual and the materials to be used. The most common positions available for assessment of skills acquired prior to one year are supine, prone, sidelying, and supported sitting. Of the assessments reviewed, the L.A.P. most completely describes positions in which to assess the individual skills. The L.A.P. specifies lying as "facedown" "on his stomach," or "on his back" (p. 33). The Callier-Azusa, Marshalltown, and the Down's Syndrome Performance Inventory rarely include positions with the description of different responses to be assessed. The three positions utilized are prone, supine and supported sitting. The Madison Public Schools Checklist specifically does not indicate which positions are used to assess which skills because the responses are to be observed as they occur naturally. This would suggest assessing the skill in any position the individual assumes or maintains in the environment. However, this implication is not clear, nor is the data sheet for this checklist conducive to assessing the same skill in more than one position. None of the assessment tools consider sidelying as possible alternative positions in which a functional reach or grasp can be observed. Where there is a position indicated, no guidelines are presented suggesting how long to maintain an individual in a position while observing a response or how often to rotate positions. Both considerations could significantly effect the performance capability of severely involved individuals.

Each of the non-standardized assessment instruments reviewed does present directions or suggestions for the materials to use in

the evaluation. The typical ring, rattle, cube, raisin, and string are included. The L.A.P., Callier-Azusa and to a lesser degree, the Marshalltown and Peabody Motor Development Scale, occassionally suggest a toy or favorite item to determine the presence of different responses. The size of the object is also inconsistently indicated; i.e., 2.5 inch pegs, 2 inch cubes, 2 inch balls, etc. However, the positioning of the material is rarely indicated. The assumption is for the experimenter to place items in midline. It is not clear, however, at what distance the objects should be placed from the individual, for how long, or what instructions should be provided. The L.A.P. and Callier-Azusa occasionally limit the number of presentation of an item. However, no assessment scale suggests positioning of items other than midline, either in an attempt to determine the extent of generalization of the response, or to identify if the response occurs when the stimulus item is presented in any of a variety of positions.

The non-standardized assessment instruments reviewed contain both a greater number and greater variety of items identified as relevant behaviors in the acquisition of functional reach and grasp than do the standardized assessment scales. The items listed can be categorized as behaviors involving reach, grasp, release, and then the coordination of these movements into midline skills and object manipulation. The Developmental Pinpoints has the most extensive listing of behaviors involved in the development of grasp. The Marshalltown adds to this information by listing some levels of prompts at which an individual could perform a skill. The overall identification of the development of a reach is not as clearly or extensively differentiated as that of the grasp. The listing for reach jumps from

identification of activation of arms with stimulation and extensor-flexor thrusting to reaching for an object. Some assessments also include hand to mouth movements or swiping objects from the face or chest as components in the development of a reach prior to the co-ordination of a reach and grasp response.

Research in the Development of Reach and Grasp Responses

Some basic research has appeared dealing with reach as separate from a grasping response. A primary investigation was conducted by Halverson (1933) in the attempt to accurately record the development of reaching movements in infants. Motion picture stop-frame analysis was used to identify such components as lateral digression of the arm, absolute distance traveled, elbow movement, and amount of forward projection.

The variables under investigation centered around the accuracy of reaching movements in infancy with variables identifying the course of accurate movement, the nature of earliest reaching movements and their development, the nature of errors in reaching, the uniformity in the nature of errors at a given age, the direction of errors, the nature of their corrections, the transformation of reaching patterns, the speed of movement, and the relative usefulness of the parts of the arm and trunk in reaching activities. Halverson studied eight children and followed the development of reach for each child from 12 to 60 weeks. During each four week age period each child was placed in a supported sitting position with a pellet or cube placed in front of him on a surface. Motion pictures were recorded of the reaching motion from an overhead and side view. Stop-frame analysis was used to identify movements during which the child got

nearest to the object after leaving a position of rest and ending in another activity. Components of reach such as lateral digressions of the arm, absolute distance traveled, elbow movement, amount of forward projection, course of the hand in reaching, reach time, continuity of movement, hand elevation, etc., were identified across the 48 week age span. The information is presented in tables which give brief descriptions of the movements across ages.

McGraw (1943) attempted to chart the emergence and integration of a series of identified phases of reaching. Six phases were identified and the percent occurrence of these responses across infants of various ages was observed and represented in graphic form. The phases generaly represented the following: A - newborn or passive with no overt response to stimuli; B - incipient flexor-extensor movements and/or rapid uncoordinated movements with arms; C - approach movements of upper extremities with movements of arms identified as circumductive, ataxic, and bilateral, and fingers extended or fisted with arm approach movements; D - manipulative and deliberate movements where reach is directed and the fingers are extended throughout motion with actual prehension occurring between the finger tips and thumb; E - a dimunition of the extension of the fingers while reaching and a glancing away when the motion is being completed; and, F - motion reduced to the essentials, with no gross movement involved. The figures presented in the study graphically depict the percent of occurrence of each phase across age in days, zero to 1200. This method of representation clearly demonstrated the acquisition and then decrease or integration of each phase of responding as more develop-

mentally advanced phases were acquired. Even though the reliability of the measurement procedures and the validity of the definitions can be questioned, this study is notable as an early attempt to represent the emergence and integration of a variety of reaching behaviors as a function of age.

Most research on the identification and measurement of reach responses attempts to determine the relationship of this behavior to visual and auditory stimulation. However, these studies are included as examples of methods to measure reach. Freedman, Fox-Kolenda, Margileth, and Miller (1969) demonstrated characteristics of the overhead and lateral reaching responses of a blind infant placed in the supine position. The investigators attempt to determine which sensory mode the infant used first to guide the reaching response. At five months the infant reached overhead when a rattle was sounded, but only reached laterally if tactile stimulation followed the sound of the rattle. Reach was defined by whether the rattle was retrieved or not implying that the physical components of a reach were already well established. Fraiberg, Seigel, and Gibson (1966) studied the search behavior of blind infants in terms of the topography of the reaching behavior in response to tactile and auditory stimuli. A stop-frame analysis was used with scoring done by agreement from a group of observers. Examples of topographies pinpointed included hands motionless, hand continues with previous motion, child conducts random search, search patterns become organized, groping gestures, orients head with arm, directed reach and recovery, etc.

McDonnell (1975), studied whether the hand had to be in the sight of the infant for reaching to occur and compared the reach-

ing of neonates and four to five month olds when site of the hand was and was not distorted. Videotaping from a position directly above the infant recorded the path of approach to an object over a measurement surface marked off in centimetered concentric circles around the midpoint of the placement of the object. A miss path was differentiated from a hit path if the object was passed while reaching was attempted. In addition, correction paths were observed when the direction of the hand crossed the line of fixation. The results indicate that view of the hand increases accuracy of the reach response of older infants with fewer corrections enroute to the target. A demonstration of the intention of reaching in the neonate was made by Bower, Broughton, and Moore (1970). They defined reaching as being oriented and expressing a distal aim or intention. Aim was determined by a film analysis of the angular relationship of the position of the hand/arm extension, the object, and the middle of the infant's body. Intent was determined by the infant's response after the reach if the object was contacted. Crying tended to result after reach for the visual projection of an object. No crying occurred if reach encountered a real object.

Some of the developmental information of the earlier research on reach has been included in selected assessment tools. However, a finer analysis of the movement arcs of the arms, the patterns, or the total time and distance involved in a reach have involved equipment and procedures too involved for most classroom application. Yet these definitions and techniques can provide a beginning for the development of applicable classroom procedures when assessing

the emergence of reach responses.

Even fewer research articles have attempted to relate the effect of the reach response on the grasp. Halverson (1937, III) studied the relation of arm position to readiness and strength of the early grasping response. He restrained the infant's arm in predetermined assumed or forced positions and tested the elicited grasp response by resistance to withdrawal of a rod. His measurements were loosely defined in such terms as firm, strong, weak, etc. The elicited response was strongest when the arm was extended, and weakest when the arm was flexed at the shoulder. In a later study, Kopp (1974), examined the variety of reach approaches when the advanced radial palmar grasp was predominant. Observation periods were divided into 60 second segments to evaluate the anticipatory motor adjustments of the arm, and 120 second segments to evaluate the retention and use of an object. An object was placed in a predetermined location while the infant was in a supported sitting position. Examples of the observation code for the approach to an object include: plane of approach in direct line or circuitous, speed of approach (less than 2 seconds or more than 3 seconds), hand position of approach (some rotation or completely rotated), and accuracy of approach. Examples of the observation code for retention include: the position of the first hand to contact the cube, first finger position of cube, finger speard, and type of grasp. Finally, movements of the second arm were also recorded. Kopp concluded that there are qualitative differences in reach and grasp actions even among normal infants. The additional range of movements present in the reach and grasp of handicapped individuals greatly increases the problem of coding re-

sponses for a reliable classroom assessment tool.

The characteristics of the grasp response were investigated early and thoroughly by Halverson. Norms were established for the relation of clinging strength to finger length and the diameter of the rod (Halverson, 1937, III), and clinging strength as compared with the right and left hand (Halverson, 1937, II). The question whether infants discriminate grasping objects by texture, by the strength of the pull on the rod, and/or by presensitization with rough or smooth objects was also identified (Halverson, 1937, I). The procedure for evaluating the grip involved measuring what proportions of the infants own body weight was supported by clinging to a rod when raised off the ground. The procedure for evaluating finger strength was similar. Discrimination was defined by whether or not the infant retained the object. The particularly human characteristic of thumb-oppostion was identified in terms of the digital postures of the thumb and fingers when grasping a variety of objects (Gesell and Halverson, 1936). The children were filmed in supine and sitting position with stop-frame analysis used to determine the position of the arm, hand, and fingers. Motion pictures were also used in a later study to document the development of the automatic grasping response in infants (Twitchell, 1965). The characteristics of finger, hand, wrist, and elbow positions during the avoiding response, traction response, reflexive grasp, and automatic grasp were described. As with the reaching response, the norms for a grasp were established prior to the development of most assessment tools. However, their inclusion as items to be evaluated has been prohibited because of a lack of reliable

and valid measurement techniques that are applicable to the classroom setting.

A Developmental Sequence for Reach and Grasp: Implications for Quantitative Measurement

The sequences identified through the basic research and expanded and translated into observable events on standardized and non-standardized assessment tools are more than adequate in describing the normal development of reach and grasp into functional manipulation. Figure 1 reflects the amount of information available for reach and grasp compared with the limited amount of data reflecting the development of midline skills and a voluntary release. It is obvious that development of manipulation comprises both a horizontal and vertical progression with various components beginning, developing, and integrating with more complex responses at different points in time. Figure 1, then, is a summary of the developmental milestones selected from all the standardized and non-standardized assessment tools reviewed. It represents the general consensus of the sequence of responses and the approximate age at which they usually occur. Discrepencies in the developmental progression or actual emergence of behaviors listed in the various assessment instruments were resolved by considering the placement of each skill by the majority of standardized tools. Figure 1 reflects the separate development of the component skills of reach, grasp, midline skills, and release as each becomes integrated into a higher level of functioning. Figure 2 displays the progression of the major component parts as they develop into the more general target skill of manipulation. The figure was developed as a logical represen-

FIGURE 1
MANIPULATION

Months	PREHENSION		MIDLINE SKILLS	RELEASE
11-12	Compares by bringing together midline carries two objects in one hand			
10-11	holds with one hand and fingers with other			
	pincer grasp	directed reach	combines objects	voluntary
9-10	attempts to secure 3 cubes	reaches for object out of reach		
8-9	radial digital grasp	reaches with index finger leading	claps hands	
	3-jaw chuck			
7-8	radial palmar grasp	reaches with fingers over extended		
6-7	grasps with raking	reaches with arm in midline	bangs objects	stabilized
	turns and regards holds two cubes pronates forearm rotates wrist			
5-6	GRASP medial palmar	REACH		
4-5	pulls ring to retrieve hit, shakes, waves grasps voluntarily	reaches directly object to mouth	reaches across transfers objects	involuntary
3-4	carries ring to mouth thumb not opposed	recovers rattle from own chest		
	manipulates ring			
2-3	grasps with reach	sweeping reaches	finger play together	
	grasps and retains for 5 seconds			
1-2	ulnar-palmar grasps of objects	arms activate with stimulation		
	hands opens and closes	circular motions hand to mouth		
	hands loosely open			
0-1	hand fisted close around object	flexion-extension mass movements	hands together	

FIGURE 1 - DEVELOPMENTAL LISTING OF BEHAVIORS LEADING TO MANIPULATION

tation of the relationship of the component parts. Each cluster of skills has the potential of developing separately from the other skills listed, and each element, 1 or 2, within a cluster can develop without the occurrence of the other element. However, both elements within a cluster on line A must be acquired before each item listed on line B can be completed developed. The same progression holds for the development of the target skill, manipulation , on line C. Assessment instruments attempting to identify the development of manipulation skills with handicapped and non-handicapped individuals must allow for monitoring the emergence of each skill separately and as it becomes integrated into higher performance patterns in order to accurately describe the potential of each person.

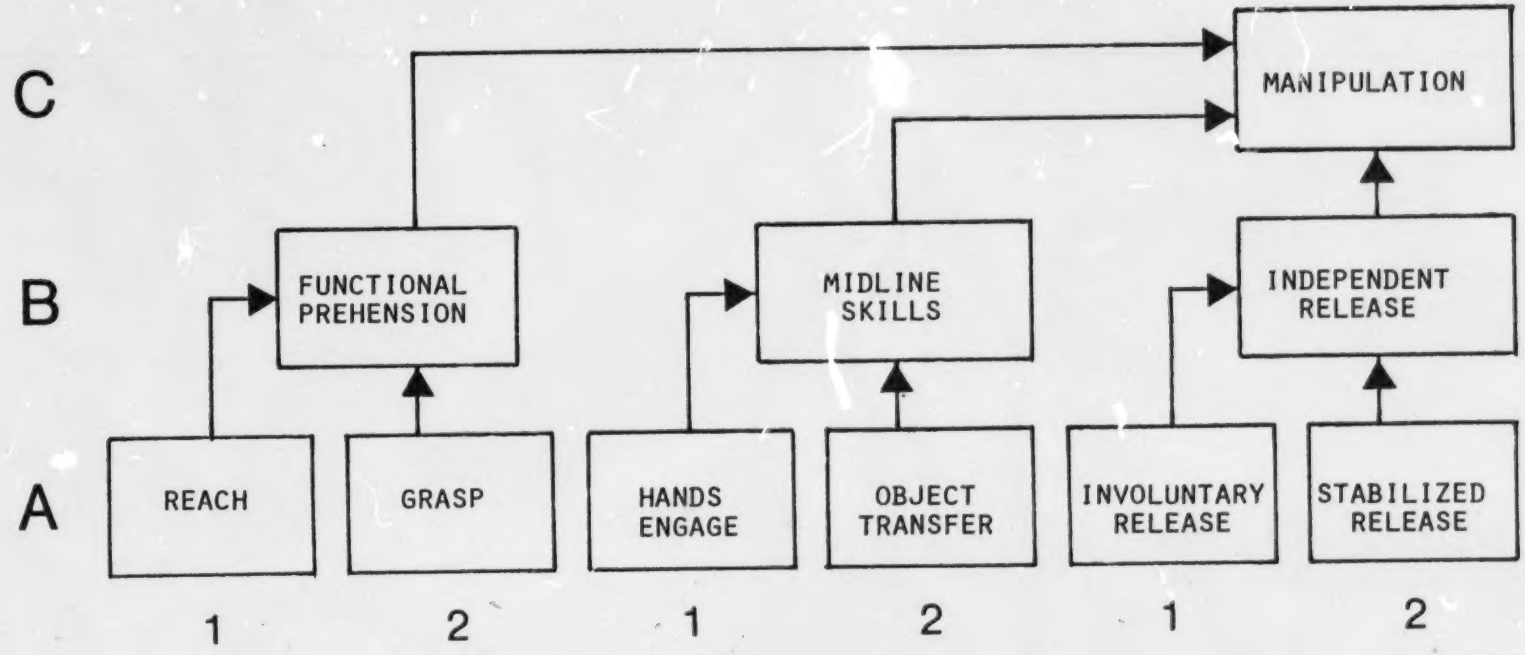

Figure 2:Manipulation Progression

NOTES

1. The Neonatal Behavior Assessment Scale (Brazelton, 1973) was included specifically because of the descriptors for the neonate's and hand movements. Unlike the other tools reviewed, it is not the function of this scale to provide an ongoing assessment of a child's development.

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